

Applications of an Optical Method for Relative Pressure and Density Characterization on SF₆ Near Its Critical Point

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We have used an optical method to measure the relative mean density of a slightly off-critical pure fluid in a constant volume sample cell. This is accomplished by measuring the position of the liquid-gas meniscus as a function of the temperature difference from the critical temperature. Careful design of the experimental cells, high performance temperature control ($\pm 10 \mu\text{K}$), and high optical resolution ($\pm 0.01 \text{ mm}$) on the meniscus height allows a precision of $5 \cdot 10^{-4}$ on the value of the average density of a fluid, relative to its critical density. Combining different well-defined orientations of the cell's dead volume relative to Earth's gravity, we use the compressibility effects to analyze the amplitude D of the power law $(P - P_c) = D(\rho - \rho_c)^\delta$ along the critical isotherm (where P is the pressure, P_c is the critical pressure, ρ is the density, ρ_c is the critical density, and δ is a universal exponent). Comparison with the results of a simple model that takes into account the varying cross sections of the cell and integrates the density profile over the total height of the cell yields the determination of D when the average density of the cell is changed. Another objective of our studies concerns the experimental determination of the "rectilinear" diameter law of SF₆ close to its critical point using a constant volume fluid cell at various calibrated average densities. Our results do not show any curvature of this law close to the critical point. Finally, an experimental determination of the absolute critical density of SF₆ is made, using a double weighing method. The precision of these results is discussed in light of each particular experimental procedure that benefits from the use of a high precision volume variation mechanism.